Evaluation of Breast Cancer, Leukemia, and Melanoma Incidence in Marblehead and Swampscott, Massachusetts, 1987-1994

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

I. INTRODUCTION

In 1997, the Massachusetts Cancer Registry (MCR) released the report *Cancer Incidence in Massachusetts 1987-1994: City and Town Supplement* (MDPH, 1997a). These surveillance data are updated annually by the Massachusetts Department of Public Health (MDPH). In that report, the neighboring towns of Marblehead and Swampscott presented elevations for certain types of cancer for the period 1987-1994. In Marblehead, statistically significant elevations were observed in the incidence of breast cancer, leukemia, and melanoma. In Swampscott, a statistically significant excess of breast cancer cases was observed. Elevations in the incidence of leukemia among females and melanoma were also found, although these findings were not statistically significant. In response to these observations, and to address environmental concerns of the community, the MDPH's Bureau of Environmental Health Assessment (BEHA), Community Assessment Unit (CAU) further evaluated the incidence of breast cancer, leukemia and melanoma in the towns of Marblehead and Swampscott. This investigation was conducted at the request of Representative Doug Petersen, the Marblehead Cancer Prevention Project and the Marblehead Board of Health. The purpose of the investigation was to determine if unusual patterns of increased cancer incidence existed at a smaller geographic level within the two towns and also to establish whether future interventions or public health actions are warranted.

II. OBJECTIVES

As previously mentioned, one of the primary purposes of this investigation was to provide a profile of the incidence of breast cancer, leukemia, and melanoma in terms of the temporal (or time) and geographic distributions of these diseases in both Marblehead and Swampscott. This approach allowed for a description of the three cancer types in each community and, specifically, within them, by census tracts. In addition, available information related to factors associated with the development of these cancers, including risk factor information, demographic and other data were evaluated. Finally, the data were evaluated in relation to several areas of environmental concern raised by the Marblehead Board of Health and established subcommittees on environmental and health issues.

This investigation is a descriptive evaluation of health outcome data for cancer. Information from descriptive analyses can be useful in determining whether or not a common etiology (or cause) is likely and can serve to identify areas where further public health investigations or actions may be warranted. Such actions may include follow-up environmental investigations or public health interventions when an excess of well-established risk factors has been identified. Descriptive studies have inherent limitations – one being that a causal relationship between cancer and possible risk factors cannot be established. Nevertheless, a descriptive evaluation of data helps to identify any patterns of factors that may exist, such as behaviors and opportunities for environmental exposures in a geographic context. In this report, the analysis of breast cancer, leukemia, and melanoma is presented and discussed in the context of the available information.

The specific objectives of this investigation were as follows:

> To examine the incidence of breast cancer, leukemia, and melanoma in Marblehead and Swampscott by smaller geographic areas within each town (i.e., census tracts) and to determine which areas in the towns may have higher or lower rates of breast cancer, leukemia, and melanoma;
>
> To evaluate the geographic distribution and spatial patterns of breast cancer, leukemia, and melanoma cases in Marblehead and Swampscott in order to determine whether a geographic pattern of cases exists in certain areas of either town;
>
> To review available information for characteristics of the population that could suggest risk factors for the development of breast cancer, leukemia and melanoma;

To review existing environmental data for hazardous waste sites, the Salem Power Plant, and other environmental sites of concern located in Marblehead and Swampscott or surrounding towns to determine if a relationship with breast cancer, leukemia or melanoma is likely;

To interpret the results of this evaluation in the context of available scientific evidence on breast cancer, leukemia, and melanoma, and to provide a clearer understanding of any patterns of disease in order to decide whether further public health actions are warranted.

III. METHODS FOR ANALYZING CANCER INCIDENCE

A. Case Identification

The observed number of cancer cases in this evaluation was derived from cases reported to the MDPH Bureau of Health Statistics Research and Evaluation's Cancer Registry (MCR) as primary site cancer cases diagnosed among Marblehead and Swampscott residents during 1987 through 1994. Massachusetts has a population-based cancer registry; regardless of where an individual is diagnosed, his or her actual residence is recorded in the cancer registry file. Cases were selected for inclusion based on the home address of the patient as reported to the hospital or the reporting facility at the time of diagnosis.

The MCR began collecting information on Massachusetts residents diagnosed with cancer in the state in 1982. All newly diagnosed cancer cases are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111s.111B). The eight-year period, 1987-1994, constitutes the period for which the most recent and complete cancer incidence data were available at the time of this analysis.

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Primary site (location in the body where the disease originated) and histology (tissue or cell type) classify the different cancer types. Epidemiological studies have revealed that different types of cancer are individual diseases with separate causes, risk factors, characteristics, and patterns of survival (Schottenfeld and Fraumeni, 1996).

As previously mentioned, three cancer types were evaluated in this investigation including cancer of the breast, leukemia, and melanoma. Only primary site cancers were included in this evaluation. Therefore, cancers that occur as the result of metastasis or the spread of a primary site cancer to another location in the body are not considered as a separate cancer and were, therefore, not included.

Occasionally, the MCR research file may contain duplicate reports of cases. The data discussed in this report have been controlled for duplicate cases by excluding them from the analyses. However, reports of multiple primary site cancer cases were included. Duplicate cases are additional reports of the same primary site cancer case. A multiple primary cancer case is defined by the MCR as a new cancer of the same histology (cell type) as an earlier cancer, if diagnosed in the same primary site (original location in the body) more than two months after the initial diagnosis (MCR. 1996). The identification of a case as a duplicate that should be excluded from the analyses is made by MCR staff after consulting with the reporting facilities and obtaining additional information regarding the histology and/or pathology of the case.

B. Calculation of Standardized Incidence Ratios (SIRs)

To determine whether elevated numbers of cancer cases have occurred in Marblehead and Swampscott or their respective census tracts, cancer incidence data were analyzed by age and gender. These two criteria were used in order to compare the observed number of cancer cases in each census tract to the number that would be expected based on the statewide cancer experience. Standardized incidence ratios (SIRs) were calculated for the period 1987-1994 for each of the three cancer types in the towns as a whole as well as for the three census tracts in Marblehead and two census tracts in Swampscott.

The census tract is the smallest geographic area for which cancer rates can be accurately calculated. Specifically, a census tract (CT) is a smaller statistical subdivision of a city or town. Census tracts usually contain between 2,500 and 8,000 persons and are designed to be homogenous with respect to population characteristics (U.S. Department Of Commerce, 1990). Marblehead is composed of four census tracts (CTs 2031, 2032, 2033 and 2041). However, CT 2041 is shared with Salem, which provides 99.0% of the population of the census tract. Therefore, for the purpose of this report, the portion of the population in CT 2041 that live in Marblehead was combined with the adjacent Marblehead CT 2031. Swampscott's population is composed of two census tracts (CTs 2021 and 2022). The geographic location and limits of Marblehead as well as Swampscott census tracts are illustrated in Figures 1 and 2.

An SIR is an estimate of the occurrence of cancer in a population relative to what might be expected if the population had the same cancer experience as some larger comparison population designated as "normal" or average. Usually, the state as a whole is selected to be the comparison population. Using the state of Massachusetts as a comparison provides a stable population base for the calculation of incidence rates. As a result of the instability of incidence rates based on a small number of cases, SIRs were not calculated when fewer than five cases were observed.

Specifically, an SIR is the ratio of the observed number of cancer cases to the expected number of cases multiplied by 100. An SIR of 100 indicates that the number of cancer cases observed in the population evaluated is equal to the number of cancer cases expected based on the comparison or "normal" population. An SIR greater than 100 indicates that more cancer cases occurred than expected, and an SIR less than 100 indicates that fewer cancer cases occurred than expected. Accordingly, an SIR of 150 is interpreted as 50% more cases than the expected number; an SIR of 90 indicates 10% fewer cases occurred than would be expected.

Caution should be exercised, however, when interpreting an SIR. The interpretation of the SIR depends on both the size and the stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on four expected cases and six observed cases indicates a 50% excess in cancer, but the excess is actually only two cases and may be the result of chance or random variation in cancer incidence. Conversely, an SIR of 150 based on 400 expected cases and 600 observed cases represents the same 50% excess in cancer, but because the SIR is based upon a greater number of cases, the estimate is more stable. It is very unlikely that 200 excess cases of cancer would occur by chance alone.

In order to calculate incidence rates, it is necessary to obtain accurate population information. The population figures used in this analysis were interpolated based on 1990 U.S. census data for each census tract in Marblehead and Swampscott (U.S. Department of Commerce, 1990). Midpoint population estimates were calculated for the time period evaluated. To estimate the population between census years, an assumption was made that the change in population occurred at a constant rate throughout the ten-year interval.

C. Calculation of 95% Confidence Interval

In addition to calculating SIRs, the statistical significance of each SIR was also assessed. A 95% confidence interval (95%CI) was calculated for each SIR to determine if the observed number of cases is significantly different from the expected number or if the difference may be due solely to chance (Rothman and Boice, 1982). A 95% confidence interval is a method of assessing the magnitude and stability of an SIR. Specifically, a 95% CI is the range of estimated SIR values that has a 95% probability of including the true SIR for the population. If the 95% CI range does not include the value 100, then the study population is significantly different from the comparison or "normal" population. "Significantly different" means there is a less than 5% chance that the observed difference between the number of observed and expected cancer cases.

For example, if a confidence interval does not include 100 and the interval is above 100 (e.g., 105-130), then there is a statistically significant excess in the number of cancer cases. Similarly, if the confidence interval does not include 100 and the interval is below 100 (e.g., 45-96), then the number of cancer cases is statistically significantly lower than expected. If the confidence interval range includes 100, then the true SIR may be 100, and it cannot be concluded with sufficient confidence that the observed number of cases is not the result of chance and reflects a real cancer increase or decrease. Statistical significance was not assessed when fewer than five cases were observed.

In addition to the range of the estimates contained in the confidence interval, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103-115) allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval (e.g., 85-450) leaves considerable doubt about the true SIR, which could be lower than or higher than the calculated SIR. A wide interval would indicate an unstable statistic.

D. Determination of Geographic Distribution

In Marblehead and Swampscott, the geographic distribution of cancer cases was determined using available address information from the MCR indicating residence at the time of diagnosis. This information was mapped for each individual using a computerized geographic information system (GIS) (MapInfo, 1996). This allowed the assignment of census tract location for each case as well as an evaluation of the spatial distribution of cases at a smaller geographic level (i.e., census tracts or neighborhoods). The geographic distribution was assessed using a qualitative evaluation of the point pattern of cases within the town and within each census tract. In instances, where the address information was incomplete (i.e., did not include specific streets or street numbers), efforts were made to research those cases using telephone books and town residential lists issued within two years of an individual’s diagnosis. Address locations were also confirmed by site visits to the area.

E. Evaluation of Characteristics of the Population

Through the evaluation of characteristics of the population, profiles can be constructed that may offer explanations to the observed patterns in the occurrence of breast cancer, leukemia, and melanoma in Marblehead, Swampscott, and their census tracts. Age at diagnosis, gender, stage of disease, histology (cancer cell type), and anatomic location of the cancers is information regularly collected by the MCR for the individuals cancer cases. Other relevant attributes of the communities related to reproductive behaviors (i.e., mean age at first birth, parity) and socioeconomic status were obtained from the MDPH, Bureau of Health Statistics, Research, and Evaluation and from the U.S. Census Bureau, respectively. However, information about personal risk factors (e.g., family history, hormonal events, diet) that may also influence the development of cancer are not collected by the MCR or any other readily accessible source, and therefore, could not be evaluated in this investigation.

Staging of breast cancer categorizes the extent of the disease and its spread at the time of diagnosis. The analysis of breast cancer in this report defines stage in four categories: localized, regional, distant, or unknown. Localized breast cancer represents a diagnosis that the tumor is invasive, but the cancer is confined to the breast. Regional indicates that the tumor has spread beyond the organ of origin (breast). A regional stage tumor may have spread to adjacent tissues or organs, lymph nodes, or both. Distant indicates that the cancer has metastasized or spread to organs other than those adjacent to the organ of origin, or to distant lymph nodes of both (MCR, 1996). Some of the cases reported to the MCR are reported with an unknown stage. An unknown stage indicates that at the time of reporting, the tumor had not been staged.

It should be noted that in 1992, the MCR began collecting data regarding breast cancer cases categorized as in situ breast cancer. Breast cancer *in situ* is defined as malignant cells within the breast ductal-lobular system without evidence of invasion of neighboring tissues (Harris et al., 1996). Therefore, the inclusion in this report of the in-situ cases is limited to a brief comparison of the percent of cases detected per year since 1992 in these towns and in the state.

IV. RESULTS OF CANCER INCIDENCE ANALYSIS

The following sections present cancer incidence rates for each of the two towns as a whole and for each of their respective census tracts for the three cancer types evaluated. As noted previously, analysis by census tract or smaller geographic area helps in understanding whether the elevated incidence of a certain cancer type observed town-wide may be explained by an increase in cases in a particular geographic area of the town. Results are presented first for the town of Marblehead and its census tracts and then for Swampscott and its respective census tracts. Tables 1 through 3 summarize cancer incidence results for Marblehead and accordingly, data for the town of Swampscott are summarized in Tables 4 through 6. As previously described, the town of Marblehead contains four census tracts. However, CT 2041 is shared between Marblehead and Salem. Because the majority of cases in this particular census tract are residents of Salem (i.e., 99%), the portion of Marblehead residents in CT 2041 were combined with CT 2031. The town of Swampscott contains two census tracts. The locations and boundaries of these census tracts are presented for Marblehead and Swampscott in Figures 1 and 2, respectively.

A. Cancer Incidence in Marblehead

1. Breast Cancer

In the town of Marblehead, female breast cancer incidence was 24% greater than expected during the period 1987-1994 (see Table 1). This elevation was statistically significant in comparison to the Massachusetts breast cancer incidence experience (95% CI=106-144). Among females, 174 new breast cancer cases were diagnosed where approximately 140 cases were expected (SIR=124). Breast cancer incidence among males in Marblehead occurred at the expected rate for the time period 1987-1994. One individual was diagnosed with male breast cancer in the town.

Review of breast cancer incidence by census tract in Marblehead showed that during the period 1987-1994, breast cancer was elevated in each of the three census tracts (see Table 1). In CTs 2031 and 2033 the elevations in female breast cancer were not statistically significant. In CT 2301, 55 cases occurred during 1987-1994 while approximately 49 cases would be expected (SIR=112, 95% CI=85-146). In CT 2033, 62 cases were observed and approximately 59 cases were expected (SIR=105, 95% CI=80-134). The difference between the observed and the expected number of cases in CTs 2031 and 2033 were 6 and 3 cases, respectively. However, CT 2032 showed a statistically significant excess of female breast cancer cases for the period 1987-1994 (see Table 1). In CT 2032, which is located in the central region of the town, 57 female breast cancer cases were observed while approximately 32 cases were expected (SIR=177), resulting in an excess of 25 cases.

2. Leukemia

In the town of Marblehead overall, the incidence of leukemia was statistically significantly elevated during the period 1987-1994. The number of cases observed town-wide was nearly twice the number that was expected (SIR=195). Among males and females combined 29 cases occurred and approximately 15 cases would have been expected. When evaluated for males and females separately, leukemia incidence among males in the town was statistically significantly elevated. Seventeen cases of leukemia occurred among males during 1987-1994 where approximately nine were expected (SIR=198). Among females in Marblehead, 12 cases occurred where approximately six cases were expected (SIR=190). These data are summarized in Table 2. The elevation observed among females in the town was nearly statistically significant (SIR=190, 95% CI=98-331).

During the 8-year period evaluated, all three census tracts in Marblehead experienced an elevation in leukemia incidence (see Table 2). CT 2031 showed a statistically significant excess of approximately six cases (SIR=203, 95% CI=101-363). Among females in CT 2031, 6 leukemia cases were observed while approximately two were expected (SIR=269). Among males in this census tract, 5 cases were observed and approximately 3 cases were expected during 1987-1994 (SIR=157). A statistically significant elevation in leukemia incidence also occurred in CT 2032 among males and females combined (8 cases observed vs. 3.4 expected). Although the rate of leukemia was greater than expected in CT 2033, this elevation was not statistically significant and was based on an excess of approximately four cases (10 observed vs. 6.1 expected, SIR=165).

When evaluated for males and females separately, slight elevations were observed in all three Marblehead census tracts. In CT 2032 three cases of leukemia among females were observed while 1.4 cases were expected. In CT 2033 leukemia incidence among females occurred approximately as expected (3 cases observed while 2.7 cases were expected). Leukemia incidence among males in CT 2032 was elevated (5 cases observed while 2 were expected) but the elevation was not statistically significant. Similarly in CT 2033 a non-significant elevation in males was observed (7 cases observed; 3.4 cases were expected). Due to the small number of cases that occurred among females in these two areas of town, statistical significance could not be evaluated.

3. Melanoma

During 1987-1994, the incidence of melanoma in Marblehead was statistically significantly elevated. Among males and females combined, 41 cases occurred where approximately 21 were expected during the 8-year period (SIR=198). Melanoma incidence was elevated among both males and females. However, the elevation observed among females was statistically significant, where 25 cases were observed and approximately 9 cases were expected (SIR=265). Among males in the town, 16 cases occurred while 11 cases were expected. This elevation was not statistically significant. Refer to Table 3 for a summary of these data.

When evaluated by census tract, melanoma incidence was elevated in all three census tracts in Marblehead. However, statistically significant elevations in this cancer were observed in the two census tracts 2032 and 2033. In CT 2032, 11 cases were observed while 4.8 cases were expected. In CT 2033, 18 cases were observed while approximately 9 cases would have been expected (SIR=207). Both of the observed elevations in CTs 2032 and 2033 were statistically significant. In CT 2031, melanoma was elevated among females but occurred approximately as expected among males. Among females, 7 cases were observed versus approximately 3 cases expected (SIR=219). Among males 5 cases occurred where four cases would have been expected (SIR = 124).

Although melanoma incidence was significantly elevated in both CTs 2032 and 2033, when evaluated for males and females separately, the elevations were due mainly to statistically significant elevations among females in CT 2033 and males in CT 2032. In CT 2032 melanoma was slightly higher among females with four cases observed and approximately two cases expected. Among males, seven cases occurred where approximately three cases were expected (SIR=264). This elevation was statistically significant. In CT 2033, a statistically significant elevation was observed among females, 14 cases occurred where approximately four cases were expected (SIR=342). Males in this census tract, however, experienced melanoma at slightly less than the expected rate (4 cases observed, 4.6 cases expected).

B. Cancer Incidence in Swampscott

1. Breast Cancer

Similar to the breast cancer pattern observed in Marblehead, a statistically significant elevation in female breast cancer was observed for the town of Swampscott as a whole. During the period 1987-1994 a 24% excess was observed (129 observed vs. 104 expected, SIR=124, 95% CI=103-147) (see Table 4). No male breast cancer cases were observed in Swampscott during period 1987-1994.

In addition, breast cancer incidence was elevated in both CTs 2021 and 2022 during the period 1987-1994. However, neither of the elevations were statistically significant. In CT 2021, 77 cases of breast cancer occurred where 63 cases were expected based on the statewide breast cancer incidence experience (SIR=122). In CT 2022, 52 cases occurred where 41 cases were expected (SIR=127). These data are summarized in Table 4.

2. Leukemia

Leukemia in the town of Swampscott as a whole and among males and females separately, occurred less often or approximately at the rate expected based on the statewide leukemia incidence experience. When evaluated by census tract, the incidence of leukemia was about as expected in both CT 2021 and 2022. In CT 2021, six cases occurred overall where approximately seven were expected (SIR=89). In CT 2022, four cases occurred where approximately five cases were expected. When leukemia incidence was evaluated separately by gender in the two CTs, the incidence was less than or equal to expected for males and for females in CT 2022. In CT 2021, leukemia among males occurred slightly less often than expected (2 observed vs. 3.6 expected) and slightly more often than expected among females (4 cases observed while 3.1 cases were expected). Leukemia incidence rates for Swampscott and its two census tracts are presented in Table 5.

3. Melanoma

During the period 1987-1994, the incidence of melanoma in Swampscott was greater than expected based on the statewide cancer incidence experience for this cancer. Among males and females combined, 21 cases occurred where approximately 15 cases were expected (SIR=142). When evaluated separately by gender, the incidence of melanoma among both males and females was slightly elevated. For males in the town, 11 cases occurred during 1987-1994 where approximately 8 cases were expected (SIR=138). Among females, 10 cases occurred where approximately 7 cases were expected (SIR=147). None of the elevations observed were statistically significant and the increases were based on three additional cases among both males and females (see Table 6).

When evaluated by census tract, melanoma incidence in Swampscott occurred more often than expected in both CT 2021 and CT 2022. In CT 2021, both males and females experienced melanoma at rates approximately equal to expected. The elevation observed was due to less than one additional case among both males and females. In CT 2022, melanoma incidence was greater than expected overall. However, the elevation was not statistically significant. Among males, 6 cases occurred where approximately 4 cases were expected (SIR=169). Among females, 5 cases occurred where slightly less than three cases were expected (SIR=185). Although melanoma incidence was elevated in this census tract, neither of the elevations were statistically significant.

C. Analysis of Geographic Distribution

Place of residence at the time of diagnosis was geocoded and mapped for each of the three cancer types to assess any possible geographic pattern of cases. In addition to quantitatively determining census-tract-specific incidence ratios for each cancer type, a qualitative evaluation was conducted to determine whether any specific cancer type appeared to be concentrated in some area(s) within any of the census tracts in Marblehead or Swampscott.

1. Breast Cancer

Review of these data for breast cancer for the town of Marblehead showed that the distribution of cases throughout the different census tracts does not present any specific pattern. Apparent concentrations of cases observed in certain geographic areas within the census tracts were consistent with the population density of those specific locations. Further, the geographic distribution of the female breast cancer cases by age or year of diagnosis does not follow any particular pattern.

In Swampscott, review of the geographic location of individual cases revealed that the cases were evenly distributed throughout each of the census tracts in Swampscott. In addition, mapping of breast cancer cases by age and year of diagnosis did not reveal any geographic pattern among breast cancer cases diagnosed in Swampscott during the period 1987-1994.

2. Leukemia

There was no specific geographic pattern of leukemia cases observed in the town of Marblehead or its census tracts. In general, most of the leukemia cases diagnosed during the period 1987-1994 in

Marblehead were located in geographic areas that were densely populated. Approximately 80% of the leukemia cases in CT 2031 were located in the southeastern portion of this census tract. The majority of the cases located in this area were age 50 years or older. In CT 2032 and 2033, leukemia cases were not found to be concentrated in any geographic area and appeared uniformly dispersed throughout each of the census tracts. In Swampscott, leukemia cases were widely dispersed throughout the town.

3. Melanoma

In Marblehead, most of the 41 individuals diagnosed with melanoma were evenly distributed throughout the town. In CT 2032 a statistically significant elevation occurred, however, the cases were largely concentrated in the eastern half of the census tract. In CT 2033 where a significant elevation in this cancer type was also observed, melanoma cases also resided in the eastern half of the census tract along the shoreline. However, neither census tract showed cases that were concentrated in close proximity to each other.

The geographic pattern of melanoma cases in Swampscott during 1987-1994 showed a distribution of cases that is consistent with the population density of the town. In CT 2021 and CT 2022, most of the cases were concentrated in the southern portion of this census tract. The large number of the melanoma cases in Swampscott was diagnosed after 1992. In addition, most of the melanoma cases were in the age groups of 20-44 and 45-64. Further discussion of the geographic distribution of cases in relation to environmental sites of concern is presented in Section VI. C.: Review of Environmental Data and Cancer Incidence.

V. RESULTS OF ANALYSIS OF RISK FACTOR INFORMATION

A. Breast Cancer

The risk of developing breast cancer can be influenced by a number of factors. Epidemiological studies have determined few well-established risk factors for this cancer type. The most well-established risk factors for breast cancer are related to genetics and specific reproductive events in women such as, age at first birth, number of births, and age at menopause (Kessler, 1992). Certain factors such as age and demographic characteristics (i.e., socioeconomic status, and racial/ethnic groups) have also been shown to be related to breast cancer risk. Available information related to some of these factors was reviewed for Marblehead and Swampscott and is discussed below.

1. Age

Breast cancer has the highest incidence rate of all cancers among women ages 35 and above, with higher incidence rates in older age groups (Devesa et. al., 1995). Breast cancer incidence and age have been shown to be related; incidence increases from age 35-45, increases at a slower rate from age 45-50, and increases at a steeper rate in post-menopausal women after age 50 (Kessler, 1992). The SIR was adjusted by age according to five-year age categories. Age-specific SIRs were used to evaluate breast cancer in Marblehead and Swampscott in comparison to age-specific rates for the state of Massachusetts as a whole.

(a.) Marblehead

In Marblehead as a whole, female breast cancer incidence tended to increase with increasing age during the time period 1987-1994. Approximately 82% of the individuals diagnosed with breast cancer were greater than 50 years old (Figure 3). The greatest number of cases were observed in the age group 65-69. As shown in Figure 4 the age distribution increased slightly in the younger age groups 30-34 and 35-39 and decreased between the age groups 40-44 and 45-49. The incidence of breast cancer cases in females age 50 or above tended to ascend until the age group 65-69. A rise in incidence at the age group of 85+ was also observed. Although breast cancer incidence in Marblehead appeared increased in the younger age groups (i.e., 30-34 and 35-39), the increases were based on a small number of cases and potentially affected the stability of the measurement in these groups. The three census tracts in Marblehead displayed a similar pattern to the town of increasing breast cancer incidence with increasing age. In CT 2032, where a statistically significant elevation of breast cancer occurred, the increasing trend was greater across all age groups.

(b.) Swampscott

In the town of Swampscott, approximately 84% of females with breast cancer were greater than 50 years old at the time of diagnosis and more than 50% of the breast cancer cases in the town were 65 years old or greater (Figure 5). The incidence of breast cancer generally increased with increasing age displaying a slight decline after age 50 and then increasing after age 69. The greatest number of breast cancer cases was observed in the 70-74 year age group. However, as shown in Figure 6, the distribution of breast cancer incidence rates according to age-specific SIRs fluctuates and appears somewhat unstable. This is likely due to the small number of cases that occurred in some of the age groups, particularly the younger age groups 30-34 and 35-39.

2. Stage at Diagnosis

(a.) Marblehead

The greatest percentage of breast cancer cases that occurred during 1987-1994 was diagnosed at a local stage (71.3%) which is similar to the pattern observed for the state of Massachusetts. Approximately 23.3% percent of breast cancer cases in Marblehead were diagnosed at a regional stage; less than 2% were diagnosed at distant stage and stage at diagnosis was unknown for 4% of breast cancer cases in the town (see Figure 7). During the period 1987-1994, the distribution of breast cancer cases according to stage at diagnosis among females in Marblehead and Massachusetts was fairly similar (see Figure 7). However, in Marblehead, the percentage of cases diagnosed at an early stage (i.e., local) was approximately 10% higher than in the state.

Annually, the distribution of breast cancer cases among females in Marblehead during the period 1987-1994 tended to shift towards an increase in the number of cases diagnosed at earlier stages (local and regional). That is, in successive years during this time period, an increasing number of cases were diagnosed at the local and regional stages and a decreasing number of cases were diagnosed at the distant stage. Across each of these years, female breast cancer cases diagnosed at local stage varied from 60% to 89.5% in Marblehead (see Figure 8). For the state of Massachusetts, the percent of local stage cases over this time period was more stable and varied from only 59.4% to 63.9%. The greatest percentage of local stage breast cancer cases in Marblehead were observed in the years 1989 (85.7%) and 1992 (89.5%). During these two years, it should be noted that no breast cancer cases were diagnosed at a distant stage.

The distribution of stage at diagnosis for breast cancer cases in Marblehead census tracts was similar to the staging distribution in the town of Marblehead as a whole (see Figure 9). In each of the census tracts in Marblehead, greater than 60% of the cases were diagnosed at earlier or local stage while 23% were diagnosed at a later and more advanced stage (i.e., regional and distant). The percentage of cases diagnosed at the local stage was highest in CT 2031 (76.4%). This percentage was greater than that observed in Marblehead or CTs 2032 and 2033. The percentage of cases diagnosed at local stage in CTs 2032 and 2033 were 68.4% and 69.4%, respectively. These percentages were slightly lower than Marblehead as a whole (71.3%), but, more importantly, higher than the state distribution of local stage diagnoses (61.6%). There were no distant stage diagnoses in CT 2033 during the period 1987-1994.

(b.) Swampscott

In Swampscott, the distribution of cases by stage was similar to that observed in Marblehead. The majority of breast cancer cases that occurred during 1987-1994 were diagnosed at a local stage (72.9%). Approximately 24% of breast cancer cases were detected at later stages of the disease (21.7% regional and 2.3% distant). Stage at diagnosis was unknown for 3.1% of the cases. See Figure 10 for the distribution of breast cancer stage at diagnosis in Swampscott. In addition, Swampscott showed a similar distribution of stage at diagnosis when compared to the state (i.e., the majority of cases were diagnosed at an early stage and a smaller percentage of cases were diagnosed at later stages). However, the percentage of local stage diagnoses was 11.3% greater in Swampscott than the state (see Figure 10).

Each year, throughout the time period 1987-1994, the percentage of local stage breast cancer diagnoses generally increased in Swampscott, while regional and distant stage diagnoses generally decreased over time. During 1988 and 1993, the greatest percentage of local stage diagnoses were observed at 87.5% and 88.9%, respectively. With the exception of the years 1987 and 1989, annually during 1987 to 1994 the percentage of breast cancer cases diagnosed earlier than that of the state as a whole was much greater. These data are displayed in Figure 11.

The distribution of breast cancer cases in CTs 2021 and 2022 followed a similar distribution by stage as seen in the town as a whole and compared to the state (see Figure 12). In CT 2021, 80.5% of cases were diagnosed at local stage and 18.2% were diagnosed at regional and distant stages. In CT 2022, 61.5% of cases were diagnosed at local stage. This percentage is lower than observed in Swampscott as a whole (72.9%) but approximately equal to the state (61.6%). The stage was unknown for 5.8% of the breast cancer cases detected among the females of CT 2022.

3. Socioeconomic Status

Higher socioeconomic status, higher education level and higher income level have been identified as factors associated with an increased risk of developing breast cancer. Indicators of socioeconomic status were evaluated and presented in Tables 7 and 8 for Marblehead and Swampscott and their census tracts, to determine whether demographic characteristics in the two towns may indicate a pattern related to risk factors for increased breast cancer.

(a.) Marblehead

Review of income and education level for Marblehead indicates that the town has a higher socioeconomic status than the state of Massachusetts as a whole. According to the 1990 U.S. Census, 27% of Massachusetts individuals have a college education or above. The median income in the state is $36,952 and approximately 8.9% of the population live under the poverty level. In Marblehead, approximately 54% of individuals have a college education or greater. The median income is $53,333 and slightly more than 3% of individuals are below poverty level.

When these factors were reviewed for Marblehead census tracts a pattern of increased socioeconomic status and increased breast cancer in Marblehead was less clear. As observed in the town as a whole, each of the three Marblehead census tracts displayed higher median income and percent college educated residents than the state as a whole (see Table 7). In addition, the percent of residents below poverty level ranged from 4-6% lower in each of the three Marblehead census tracts than that observed for the state as a whole. However, these factors do not show remarkable differences across the census tracts. In CT 2032, which had a statistically significant elevation of breast cancer cases during 1987-1994, the socioeconomic indicators do not substantially differ from the other two census tracts and for Marblehead overall.

(b.) Swampscott

Swampscott and its census tracts also indicate a higher socioeconomic profile than Massachusetts as a whole (see Table 8). In Swampscott, about 45.2% of residents 25 years or older have a college education or greater versus 27% in the state as a whole. The median household income is greater in Swampscott as compared to Massachusetts ($53,530 vs. $36,952) and the percent of the population below poverty level is 5% lower (3.9% in Swampscott vs. 8.9% in Massachusetts).

In both CTs 2021 and 2022, median household income and education level were greater than the state as a whole and percent below poverty level was less than the state. CT 2021 showed higher educational level compared to the town of Swampscott as a whole (45.2%) and the state (27.0%) and CT 2022 had a higher median household income than Swampscott as a whole or the state.

4. Reproductive Characteristics

Epidemiologic studies have shown that a number of reproductive factors increase a woman's risk for developing breast cancer. High levels of estrogen at certain ages associated with specific reproductive events in a woman's life, such as early age at menarche, age at first full-term pregnancy, and low parity (i.e., having few or no children), increase the risk of developing breast cancer (Henderson et. al., 1996; Lipworth, 1995). The risk of breast cancer has been shown to increase linearly with age at first live birth. Women who give birth for the first time after age 30 have shown a four to five fold excess in breast cancer risk (Brinton et. al., 1983).

Available data regarding mean age at first birth and parity among Marblehead and Swampscott women for the towns as a whole were reviewed to determine whether these factors may have changed throughout time in the two towns and to determine whether these factors may suggest a relationship to a pattern of increased breast cancer. It should be noted that this information provides an indication of the overall prevalence of these factors in the general population of Marblehead and Swampscott that may indicate a pattern that correlates with increased breast cancer incidence. This information however is not specific to the individual cases of breast cancer discussed in this report and therefore may not necessarily indicate an increased risk among this group of individuals.

(a.) Marblehead

Compared to the state as a whole, Marblehead presented generally lower birth rates than Massachusetts throughout the 15-year period 1975-1990 (see Figure 13). Overall, the general birth rate in Marblehead increased by 45% from 35.4 per 1,000 in 1975 to 51.3 per 1,000 in 1990. In 1975, Massachusetts had a general birth rate of 58.3 per 1,000 females, which increased to 62.2 per 1,000 females in 1990. Although the birth rate increased by 45% in Marblehead throughout this period, the rate in Marblehead in 1990 remained lower than the birth rate in Massachusetts (51.3 in Marblehead vs. 62.2 in Massachusetts).

Figure 14 presents mean age at first birth for women of reproductive ages from 15 to 44 years in Marblehead and Massachusetts. In 1975, the mean age at first birth among Marblehead women was 27.8 years and rose slowly to 30.6 years in 1990, indicating a 10.1% increase in age over the 15-year period evaluated. In Massachusetts, a similar trend was observed where the mean age at first birth increased from 1975 to 1990. However, the mean age at first birth in Marblehead was approximately five years greater than that observed in Massachusetts throughout the entire 15-year period evaluated.

Not only did the birth rate increase in Marblehead during the period 1975-1990, but this increase was more pronounced among older females in the population (i.e., age 30 and above). Compared to Massachusetts, Marblehead females presented lower first birth rates at younger ages (15-29) and higher first birth rates at older ages (30-44) during the period 1975 to 1990. The first birth rate among females between ages 30-44 years old in Marblehead changed remarkably in comparison to females in the age group 15-29 during the period 1975 to 1990 (see Figure 15). In 1975, females in Marblehead ages 30-44 years old had a first birth rate of 10.5 per 1,000 females. However, the occurrence of first births among females in Marblehead in this age group increased to 21.4 per 1,000. The rate of first birth for females, age 15-29 years was 20.4 per 1,000 in 1975. For 1990, the rate of first birth for Marblehead women aged 15–24 was 22.9 per 1,000 females. In comparison to first birth rates among Massachusetts females, the first birth rate among women aged 30–44 in Marblehead was more than twice the rate in Massachusetts in 1975 (10.5 per 1,000 in Marblehead vs. 4.9 per 1,000 in Massachusetts).

(b.) Swampscott

The general birth rate in Swampscott increased notably among females aged 30 years or older. The general birth rate of Swampscott increased from 34.7 per 1,000 in 1975 to 52.1 per 1,000 in 1990. In comparison with Massachusetts, Swampscott showed lower general birth rates during the period 1975 to 1990. Massachusetts' general birth rate in 1975 was 58.3 and rose to 62.2 in 1990. Moreover, the general birth rate in Swampscott in 1990 (52.1) was lower than the general birth rate in Massachusetts for 1975 (58.3 per 1,000). These data are presented in Figure 13.

From 1975 to 1990, the mean age at first birth among females in reproductive ages (15-44) in Swampscott and in Massachusetts increased (see Figure 14). The percent change in the mean age at first birth from 1975 to 1990 was 14.5% in Swampscott and 13.4% in Massachusetts. However, the mean age at first birth of females in Swampscott through this 15-year period demonstrated slightly higher rates than among females in Massachusetts. In 1975, the mean age at first birth was 25.6 years; while in Massachusetts, it was 23.1 years. For 1990, the mean age at first birth among females in Swampscott was 29.3 years in comparison to a mean age of 26.3 years observed among females in the state. A difference of two to three years in the mean age at first birth between Swampscott females and Massachusetts females was observed throughout the period of time evaluated.

In addition, the rates of first births in Swampscott increased among younger women as well as women aged 30-44 from 1975 to 1990 (see Figure 16). However, the most drastic change is observed in the older age group (30-44), from 2.3 per 1,000 females in 1975 to 22.1 per 1,000 females in 1990. During this period, the rate of first births among older females (30-44) in Swampscott changed from being less than that for Massachusetts (2.3 in Swampscott vs. 4.9 in Massachusetts) to greater than that for the state (22.1 in Swampscott vs. 15.6 in Massachusetts).

B. Leukemia

Leukemia is the most common type of cancer diagnosed among children. However, leukemia also occurs among adults, usually of older ages. There are five main types of leukemia with notable differences in the age distribution by subtype (NCI, 1996). Acute lymphocytic leukemia (ALL) is most common among children. Chronic lymphocytic leukemia (CLL) rarely occurs before age 30, after which the incidence increases rapidly with increasing age. The majority of CLL cases (i.e., 90%) occur in people over 50 years old. Acute myelocytic leukemia (AML) displays the highest incidence among young and middle-aged adults. Chronic myelocytic leukemia (CML) can occur at any age, but is most often observed in individuals from age 30-50 years old. Rates for all types of leukemias are higher in males than in females.

1. Age

The median age of leukemia cases in Marblehead reported during the period 1987-1994, was 67 years old. The majority of cases (76%) were greater than 50 years old at the time of diagnosis. Three cases of childhood leukemia occurred in Marblehead during the period 1987-1994. In Swampscott, the median age of leukemia cases was 64 years. Approximately 80% of the cases were greater than age 50 at the time of diagnosis. No cases of childhood leukemia were reported in Swampscott during the period 1987-1994.

2. Histology (Cell Type)

In Marblehead, review of the histologic types of each of the leukemia cases indicated a distribution expected for adult leukemia. Approximately 31% of the leukemia cases diagnosed during 1987-1994 were chronic lymphocytic leukemia (CLL) and 21% of the cases were diagnosed with acute myeloid leukemia (AML). All of the childhood leukemia cases were diagnosed with acute lymphocytic leukemia (ALL). The distribution of leukemia cases in Swampscott according to histologic type was similar to that observed in Marblehead. During the period 1987-1994, four of the 10 cases were diagnosed with CLL, and five were diagnosed with AML. No cases of childhood leukemia or ALL were observed.

C. Melanoma

The incidence of malignant melanoma increases with age and rises steeply until the age of 50. Melanoma does occur frequently among younger individuals but the incidence is highest primarily among middle-aged individuals (Armstrong and English, 1996). The incidence of melanoma is also higher among women than men. Melanoma distributes differently by location on the body according to gender. Among females, melanoma occurs more frequently on the lower limbs and among males this cancer occurs more frequently on the trunk (Armstrong and English, 1996).

1. Age

The majority of melanoma cases diagnosed in Marblehead during 1987-1994 were 45 years of age or older (i.e., 73%). The minimum age observed among the cases identified in this town was 26 years and the maximum was 90 years. The highest percentage of cases was observed in age groups 45-64 and 65-74. The median age in Marblehead was 60 years. In Swampscott, the median age of melanoma cases at the time of diagnosis was 59 years. The highest percentage of female melanoma cases diagnosed in Swampscott, were greater than 50 years old.

2. Anatomic Site & Gender

Of the 41 melanoma cases diagnosed in Marblehead, 27% were detected on the arm & shoulder, 22% on the face, 24% on the leg & hip, and 27% on the trunk. The distribution of melanoma cases by gender and anatomic site are presented in Figure 17. The distribution of the female melanoma cases by anatomic site was as follows: 40% on the leg & hip, 28% on the arm and shoulder, 16.0% on the face, and 16.0% on the trunk body site. Among male cases in Marblehead, the largest percentage of melanomas were located on the trunk (43.8%), followed by diagnoses on the face (31.3%), and the arm and shoulder (25.0%). These patterns are consistent with expected patterns of melanoma among males and females.

In Swampscott, the distribution of melanomas according to anatomic site was as follows: 9.5% on the face, 28.6% on the arm and shoulder, 28.6% on the leg and hip, 28.6% on the trunk, and 4.8% that could not be identified. Figure 18 presents the distribution of melanoma cases in Swampscott by gender and anatomic site. Among female melanoma cases, the majority of diagnoses were made on the lower body in the leg and hip region (40.0%), followed by diagnoses on the arms and shoulders (20.0%), trunk (20.0%), and face (10.0%). Among males in Swampscott, the distribution of melanomas by anatomic site was 36.4% located on the upper body (i.e., arms and shoulder), 36.4% located on the trunk, 18.2% on the leg and hip, and 9.1% on the face. Again, these data are consistent with data available from comparison studies.

VI. COMMUNITY ENVIRONMENTAL CONCERNS AND CANCER INCIDENCE

Marblehead residents, the Marblehead Board of Health, established subcommittees and the Marblehead Cancer Prevention Project have raised a number of concerns regarding environmental factors in the town and the potential relationship to increased cancer incidence. The predominant concern focused on the Salem Harbor Generating Station (SHGS) and whether historical opportunities for exposures to the facility emissions may have played a role in the elevated rates of breast cancer, leukemia, or melanoma in the town. Other concerns have been raised over the location of hazardous waste sites, dry cleaning facilities, boat yards, and other potential sources of exposures and possible concentrations of cancer cases near these sites. The following sections discuss the distribution of cancer cases relative to opportunities for exposures from the various sources of concern.

A. Salem Harbor Generating Station (SHGS)

One of the main environmental concerns expressed by local residents in Marblehead was whether the SHGS might play a role in the elevated rate of breast cancer, leukemia, or melanoma in the town. To address this concern, the MDPH/BEHA reviewed available information on historical emissions from the facility, as well as ambient air monitoring results from areas influenced by the facility's operations. At the request of MDPH/BEHA, the Massachusetts Department of Environmental Protection (MDEP) also conducted air modeling of historical emissions from the SHGS to determine the specific geographic areas that were most impacted by SHGS emissions. Because the average level of long-term exposure is more likely to affect the risk of chronic disease such as cancer, this modeling was limited to estimating average ambient concentrations, rather than short-term peak exposures. Thus, CAU staff could then qualitatively evaluate the distribution of cancer cases during the period 1987-1994 relative to the geographic areas most impacted by SHGS emissions.

Appendix A contains MDPH/BEHA's overview of environmental information related to the SHGS. The results of this evaluation are summarized below and discussed in relation to cancer incidence in Marblehead and Swampscott.

The SHGS began operation in 1951. During the ensuing 30+ years, a number of important changes in plant operation resulted in changes in areas of greatest impact from the facility's emissions. From 1951 to 1969, the plant burned primarily coal, and emissions exited from three separate 250-foot stacks. A fourth stack, 500 feet tall, was built in 1972. From 1969 to 1982, the facility burned primarily oil. Between early 1982 and late 1984, a fifth stack, 430 feet tall, was constructed. Since 1984, emissions from the facility have been exiting from the two tallest stacks, and the three oldest (and shortest) stacks are no longer in use. In addition, the facility is currently burning both oil and coal. The location of the SHGS is shown in Figure 19.

Given this operational history, MDEP performed air dispersion modeling to estimate the most likely maximum impact locations and concentrations of two pollutants used as surrogates in the modeling—particulate matter (PM) (total) and nitrogen oxides (NOx). It is expected that other pollutants emitted from the facility would distribute similarly and likely impact the same locations. Three different scenarios were modeled to see how the changes in facility operations (e.g., stack height, fuel burned) may have affected predicted areas of greatest impact:

1. 1951-1969, when the facility burned primarily coal and emissions exited from three 250-foot stacks

2. 1969-1982, when the facility burned primarily oil and emissions exited from four stacks

3.1984-present, when the facility burned both coal and oil and emissions exited from two tall stacks (i.e., 500 feet and 450 feet).

In these three scenarios, impact locations and concentrations, and, to some extent, the contaminants emitted are expected to differ because of changes in stack parameters (e.g., height), emissions characteristics (e.g., emission rates), loading, and the type of fuel burned. The time period of most interest from modeling the facility's historical emissions would be 1951-1982 for cancers diagnosed in Marblehead or Swampscott during the 1987-1994 period. This is because cancer in general has a long latency period (i.e., the interval between first exposure to a disease-causing agent(s) and the appearance of symptoms of the disease (Last 1995) that can range from 10 to 30 years and in some cases may be more than 40 or 50 years (Bang 1995, Frumkin 1995). For most cancers, the latency period is an interval usually between 12 to 25 years (Bang 1996; Frumkin 1996).

Results of the MDEP modeling for the various scenarios discussed above are shown in Figures 1 through 6 of Appendix A. As mentioned above, these results show average ambient concentrations. Because emissions from the shorter stacks did not disperse as well as from the taller stacks used after 1984, the maximum impact locations during 1951-1982 were closer to the facility than after 1984. During 1951-1982, the area predicted to have had the greatest opportunities for exposure is in Marblehead, in the general vicinity south of Cloutman Point and approximately two kilometers southeast of the facility. The next highest impacts are located nearby at Naugus Head and south of Fluen Point. All of these areas of Marblehead are located in the northern section of CT 2033. After 1984, the area predicted to have the greatest opportunities for exposures to emissions from the facility are in the Wyman Hill/Great Hill area of Manchester-by-the-Sea. It should be noted, however, that there was a relatively small difference in actual predicted concentrations between the area of greatest impact and other areas of Marblehead (e.g., for

PM during 1951-1968, the maximum impact area had concentrations of 6m g/m^3, while most of the town was above 1m g/m^3 and the lowest impact areas of Marblehead had concentrations a little less than 1 m g/m^3).

The modeling results and available ambient air monitoring data for locations in Marblehead (including where the maximum predicted impact areas were), Salem, Beverly, and Danvers indicated that for those parameters modeled or measured, the average concentrations have not exceeded health-based National Ambient Air Quality Standards (NAAQS) set by the U.S. Environmental Protection Agency (USEPA). However, little data are available for power plants in general, including the SHGS, with respect to other hazardous air pollutants (HAPs) that may be emitted by these types of facilities. Although the USEPA has reviewed national data, conducted air modeling, and evaluated health risks from predicted ambient air concentrations of selected HAPs (e.g., mercury, radionuclides, arsenic, dioxins), these national data cannot be used to definitively evaluate possible health concerns associated with HAPs emitted specifically from the SHGS. Furthermore, it is not known to what extent HAPs that are persistent in the environment (e.g., mercury, dioxins) may have been emitted from the SHGS historically such that these emissions may have resulted in elevated soil concentrations in nearby areas.

B. Cancer Incidence in Relation to Impact Areas from SHGS

Review of the incidence of breast cancer, leukemia, and melanoma in Marblehead revealed no apparent pattern relative to emissions from the SHGS. During the period 1951-1984, the maximum impact locations of emissions were along the northern border of Marblehead in the general vicinity of Cloutman's Point, Fluen Point, and Naugus Head, all located within CT 2033. Furthermore, review of the geographic distribution of breast cancer, leukemia, and melanoma cases revealed that none of the individual cases were located in these areas of CT 2033. In addition, breast cancer and leukemia incidence rates were most elevated in Marblehead in CTs 2031 and 2032. Breast cancer among females in CT 2032 was statistically significantly elevated during 1987-1994, while breast cancer among females in CT 2033 occurred slightly more often than expected during this time period (62 case observed versus about 60 expected). Leukemia was statistically significantly elevated among males and females combined for both CTs 2031 and 2032, while a non-statistically significant excess of about four cases occurred in CT 2033 (10 cases observed versus about 6 expected).

Melanoma was statistically significantly elevated in CT 2033, as well as in CT 2032. However, most of the cases in CT 2033 resided in the eastern portion of the census tract and not in the northern portion of the tract where the greatest opportunities for exposure to the facility's emissions were predicted. Furthermore, consistent trends in elevations among males or females were not observed in the two census tracts with significant elevations. In CT 2033, melanoma was statistically significantly elevated among females (14 observed versus about 4 expected), but occurred slightly less often than expected among males (4 observed versus 4.6 expected). In CT 2032, melanoma was statistically significantly elevated among males (7 observed versus 2.7 expected). Among females, about two excess cases occurred in this census tract (4 cases observed versus about 2 expected).

It should be noted that evaluation of the geographic distribution of cancer incidence relative to areas of impact from the SHGS emissions is somewhat limited in that little difference exists between modeled pollutant concentrations between areas of greatest impact and those of least impact within Marblehead. Nonetheless, our qualitative evaluation of the distribution of cancer cases within each census tract did not reveal apparent concentrations of cases in any particular area of Marblehead.

C. Other Environmental Concerns

In addition to the SHGS, the community has expressed a number of other environmental concerns. MDPH/BEHA evaluated residences of those individuals diagnosed with breast cancer, leukemia, or melanoma during the 1987-1994 period relative to locations of hazardous waste sites (i.e., 21E sites) as documented by the MDEP. In addition, MDPH/BEHA conducted a similar evaluation in relation to other sites identified by the community as being of particular concern, such as dry cleaning facilities and boat yards.

The most recent information regarding sites located in the towns of Marblehead and Swampscott where releases or potential releases of oil and hazardous materials has occurred and have been reported to the MDEP was reviewed. These sites were mapped and the proximity of these sites to breast cancer, leukemia and melanoma cases was assessed. Under Chapter 21E (also known as State Superfund) of the Massachusetts General Laws (M.G.L.) enacted in 1983, the MDEP investigates potentially hazardous site in the state and conducts and oversees cleanup of these sites. These sites are regulated according to M.G.L. Chapter 21E and the Massachusetts Contingency Plan (MCP) 310 CMR 40.0000.

Massachusetts sites regulated under the MCP and listed as a site prior to October, 1993 are categorized as Confirmed sites, Locations to be Investigated (LTBI), Waiver Status, Remedial or Deleted (MDEP 1993). Sites with Confirmed status are locations confirmed by the MDEP to be a disposal site and for which remedial response actions have not yet been completed. LTBIs are locations the MDEP considers reasonably likely to be disposal sites but are as yet unconfirmed. Waiver status are locations confirmed by the MDEP to be non-priority disposal sites, and where responsible parties have been authorized to proceed with response actions without MDEP oversight. Remedial status sites are sites at which a remedial action has been completed and for which no further actions are planned. Deleted sites are locations, which are not disposal sites, or where information exists which indicates no further assessment or cleanup action is warranted (MDEP 1993).

A total of 19 hazardous waste sites or reported potential release areas were identified by the MDEP as located in Marblehead. See Figure 20 for the locations of these sites. Of these sites one was listed as Unclassified Confirmed, 10 were listed as LTBI, three sites have Waiver status, and the status of five sites was undetermined. These sites are also classified by the type of contamination present at the site. Sites may be listed as having petroleum contamination (i.e., gasoline, diesel, and fuel oils) hazardous contamination (i.e., metals, organic compounds, volatile organic compounds (VOCs), and pesticides) or both, a combination of petroleum and hazardous contaminants. In Marblehead, 13 sites contained petroleum contamination, three sites contained hazardous materials, two sites contained both petroleum and hazardous materials and the type of contamination at one site was undetermined.

A total of 14 sites were identified by the MDEP as located in Swampscott (see Figure 21). Of these 9 were listed as LTBI, two sites have Remedial status, and the status of three sites was undetermined. Nine of these sites contained petroleum contamination, one site contained both petroleum and hazardous materials and the type of contamination at four sites was undetermined. The locations of these sites are presented in Figure 21.

Community members in Marblehead have also expressed concerns about other sites located in the town that may potentially be of environmental concern. A list of these sites was provided by the subcommittees of the Marblehead Board of Health and includes locations of dry cleaners, boat yards, and industrial facilities. The locations of these sites are presented in Figures 22, 23 and 24. MDPH/BEHA reviewed the location of these sites in relation to the geographic distribution of breast cancer, leukemia and melanoma in the town.

Review of the geographic distribution of cancer cases in relation to MDEP 21E sites in Marblehead and Swampscott did not demonstrate any specific pattern in either town or within the census tracts. In addition, there was no apparent spatial pattern of environmental sites of concern identified in Marblehead in relation to the location of breast cancer, leukemia or melanoma cases in the town.

VII. DISCUSSION

While elevations were noted in the incidence of cancers of the breast, leukemia and melanoma during the period 1987-1994 in the towns of Marblehead and Swampscott, further analysis of smaller geographic areas within these two towns demonstrated no specific pattern of cancer. In Marblehead, census tract analysis revealed that breast cancer was statistically significantly elevated in one census tract (CT 2032) located in the central portion of the town. CTs 2031 and 2033 experienced slightly increased breast cancer rates when compared to the statewide incidence (i.e., excesses of five and three cases, respectively). Leukemia incidence was statistically significantly elevated overall in two Marblehead census tracts (CTs 2031 and 2032). However, the number of cases was relatively small and the fairly wide 95% Confidence Intervals (CIs) indicate that these SIRs are somewhat unstable. Melanoma incidence was statistically elevated in CTs 2032 and 2033, primarily due to significant increases among females in CT 2032 and among males in CT 2033.

In Swampscott, further evaluation of earlier incidence patterns revealed no statistically significant elevations in either census tract for breast cancer, leukemia or melanoma. Breast cancer was elevated in both CTs 2021 and 2022, but again the increases were not statistically significant, indicating a slightly increased incidence of this cancer across the town. Leukemia occurred less often than expected in both Swampscott census tracts. Melanoma incidence occurred nearly equal to expected in CT 2021, with approximately one additional case during the 8-year period evaluated. In CT 2022, melanoma incidence was elevated but not significantly and the increase was observed generally among both males and females in this area of town.

With the exception of melanoma cases in CTs 2032 and 2033 in Marblehead, the geographic distribution of the three cancers revealed no specific pattern of concentration in any one area in either Marblehead or Swampscott. In CTs 2032 and 2033 in Marblehead there was no apparent clustering of cases in close proximity to each other in this area of the town, but cases appeared generally more concentrated along the eastern shoreline of this census tract. Based on the characteristics of incidence for these cancers, there was no apparent pattern with respect to elevations across gender or geographic location in the two towns. In addition, based on the information reviewed in this analysis related to risk factors for development of these cancer types, it appears unlikely that a single factor, including environmental factors, was primarily responsible for increased cancer incidence in either the towns of Marblehead or Swampscott. A number of factors or combination of factors may influence the development of the cancer types evaluated in this investigation, particularly breast cancer. Further discussion of the epidemiology and risk factors for these cancer types as it relates to cancer incidence patterns in Marblehead and Swampscott is presented below.

A. Breast Cancer

Although breast cancer is one of the most studied types of cancer, it is not clear what factor or combination of factors specifically causes it. Recently, it has been hypothesized that breast cancer appears not to be one disease (Boyle and Leaky, 1998; Broedres and Verbeek, 1997). Investigators suggest that the heterogeneity of this disease is evident in view of the fact that some types of breast cancer tend to be more aggressive and that some may depend more highly on estrogen for growth than others. In addition, the possibility exists that each form of breast cancer has a different "cause" or etiologic (causative) factors that the effects of those factors may be greater than others (Broeders and Verbeek, 1997).

Some of the better established risk factors for breast cancer are: age, demographic characteristics (e.g., gender, racial and/or ethnic group, and socioeconomic status), previous history of breast cancer or carcinoma *in situ,* benign breast disease, family history, and genetic predisposition. Other established risk factors include radiation, factors related to menstruation (age at menarche, menstrual cycles, age at menopause), pregnancy (age at first birth, number of births), and obesity. Most of the well-established risk factors for breast cancer are related to genetics and specific reproductive events in the life cycle of a woman (Kessler, 1992). Other risk factors that play less certain roles in the development of breast cancer are alcohol, oral contraceptives, hormone replacement therapy, diet, breast-feeding, physical activity and the environment.

Breast cancer is the second most common type of cancer among women. The American Cancer Society (ACS) estimates that for 1999, 176,000 new breast cancer cases would be diagnosed in women (ACS, 1999b). During the 1980's, breast cancer increased about 4% per year in the United States. In recent years, nationally, the incidence of this disease leveled off to about 110 cases per 100,000.

During the ten year period 1984-1994, breast cancer was the leading type of cancer among females in Massachusetts (MDPH, 1997b). Throughout the period 1987-1994, breast cancer was the second leading cause of death among women in the state, exceeded only by lung cancer. Age-specific breast cancer incidence rates have increased around the world and mostly among women in older age groups (van Dijck et al, 1997). In Massachusetts, the age-adjusted breast cancer incidence rate rose 0.6% from 1987 to 1994, indicating a slow increase compared to the change experienced from 1982 to 1986 (27.6%). Among females in Massachusetts during 1987-1994, the highest age-specific breast cancer incidence was observed in the age groups 75-79 and 85+ (MDPH, 1997b).

It is important to note that the age-specific pattern observed in Marblehead and Swampscott is consistent with the observed trends in this cancer type nationally and in the state. In Marblehead and Swampscott, the vast majority of breast cancer cases were diagnosed in women age 50 or older. In Marblehead CT 2032, a statistically significant elevation of breast cancer was observed in age groups 60-64, 75-79 and 85+ which appeared to contribute strongly to the increased total rate observed in the town.

Among other factors that may be related to an increased incidence of breast cancer in Marblehead and Swampscott are more accurate registration and early diagnosis of the disease. The benefits of early detection provided by mammography examination are well known (Forrest, 1990; van Dijck, et. al., 1997; Alberg and Helzsouer, 1997). Without screening, breast cancer in older women is diagnosed at a more advanced stage than in younger women (van Dijck, et al., 1997). After menopause, a great part of breast tissue is substituted by fat, which makes breast cancer detection using mammography easier in older women (van Dijck et al., 1997). Therefore, examination of the distribution of breast cancer by stage at diagnosis is one of the methods used to monitor the efficacy of screening programs. Review of the distribution of breast cancer stage at diagnosis reveals whether cases are being diagnosed more frequently at earlier or later stages of the disease. This provides an indication of whether increased breast cancer screening may be related to an increased incidence of the disease as a result of an increase in the number of breast cancers detected in a particular area.

In both Marblehead and Swampscott, as in the state as a whole, the majority of breast cancer cases were diagnosed at the local or early stage of disease. However, the proportion of local stage diagnosis in both these communities was greater than in the state as a whole (approximately 10-11% higher as compared to 61.6% for Massachusetts (see Figures 7 and 10)). Moreover, the annual distribution of stage at diagnosis revealed a trend of increased early stage diagnosis and decreased later stage diagnosis over time. Thus, the distribution of breast cancer stage at diagnosis in Marblehead and Swampscott support that detection techniques in these towns are likely effective in identifying the cases at an early stage, and it may be related to statistically significant elevations of breast cancer observed in these areas.

With respect to reproductive behavior among women in these communities, Marblehead and Swampscott women generally revealed lower birth rates during 1975-1990 in comparison to women in the state of Massachusetts. In addition, both towns displayed higher mean age at first birth among women in reproductive ages 15 to 44, with a sustained difference of 5 years in Marblehead and 3 years in Swampscott.

Other patterns displayed by the review of reproductive factors among females in Marblehead and Swampscott are in the degree of parity and in the number of births. Throughout the period 1975 to 1990, women of childbearing ages (15-44) in Marblehead and Swampscott had a tendency to have fewer children than females in the state as a whole. In 1990, the general birth rates in Marblehead and Swampscott were lower than the birth rates in Massachusetts throughout the fifteen-year period (see Figure 13). Based on a review of reproductive factors over time, women in Marblehead and Swampscott are having fewer children and at later ages of childbirth.

The evaluation of demographic and reproductive indicators in Marblehead and Swampscott present a profile of higher socioeconomic status and higher prevalence of certain risk factors in these two communities consistent with what is known about an increased risk of breast cancer. Demographic variables such as, median income and education levels indicate that both Marblehead and Swampscott are towns with a higher socioeconomic status than the state. Higher socioeconomic status in part might help explain elevations of breast cancer observed in these two towns as it relates to the state as a whole.

Studies have shown that women of low socioeconomic status (SES) tend to have lower screening participation rates than those in higher SES categories (Segnan, 1997). In addition, higher rates of breast cancer incidence in women with higher socioeconomic status are believed to reflect different patterns in factors such as diet, increased access to medical care (i.e., early detection) and reproductive behaviors (parity, age at first birth, and age at menarche). Although the census tracts in Marblehead and Swampscott are somewhat uniform in terms of socioeconomic characteristics and do not show a clear pattern related to elevations in breast cancer, the communities as a whole display a pattern of higher socioeconomic status and reproductive factors consistent with an increased risk of breast cancer that appear primarily responsible for the elevated breast cancer rates in these communities.

In addition to the risk factors discussed previously, a number of other factors have been considered in the cause of breast cancer. A family history of breast cancer is an indicator of increased breast cancer risk. A woman whose mother, sister, or daughter had breast cancer has two to three times the risk of developing breast cancer than a woman without a family history (Kelsey, 1993). Epidemiological studies have found that females with a first-degree relative (mother, sister, or daughter) with premenopausal breast cancer have a 3-fold risk of developing breast cancer. Meanwhile, no increased risk has been found for females with a first degree relative with a postmenopausal breast cancer diagnosis (Broeders and Verbeek, 1997). If women have a first degree relative with bilateral breast cancer (cancer in both breasts), then the risk increases five-fold (Broeders and Verbeek, 1997). Moreover, if women have a mother, sister or daughter with bilateral and premenopausal breast cancer, the risk of developing breast cancer increases nine fold (Broeders and Verbeek, 1997). In addition, twins have a higher risk of breast cancer compared to non-twins (Weiss et al, 1997). Unfortunately, data on family history of cancer is not available through the Massachusetts Cancer Registry and therefore could not be evaluated in this investigation.

It is estimated that between 5% to 10% of breast cancers are inherited. In 1994 and 1995, two genes BRCA1 and BRCA2 were discovered, and this genetic predisposition is estimated to account for approximately 40% to 50% of all the hereditary breast cancers in the general population (ACS, 1998). It has also been estimated that 50% to 60% of the persons who inherit BRCA1 or BRCA2 mutations will develop breast cancer by the age of 70 (ACS, 1998).

A woman’s breast cancer risk is suspected to be in great part determined by the cumulative exposure of the breast (tissue) to estrogen and progesterone (hormones present in a woman’s body)(Henderson, et al, 1996). Since during pregnancy the levels of estrogens are higher than during any other period of a woman’s life, it is suspected that early exposures to estrogen during fetal development might play a role in the risk of developing breast cancer later in life. Researchers have found that women whose mothers had toxemia during pregnancy (a condition associated with low levels of estrogen) had a statistically significant reduced risk of developing breast cancer. Some studies have shown that neonatal jaundice, severe prematurity, and being a fraternal twin are factors associated with increased levels of estrogen, and these factors may also increase the risk of developing breast cancer later in life (Ekbom, et al, 1997). Evidence from some studies that have included large numbers of long-term users of estrogen replacement therapy indicate a modest (less than two-fold) elevation in risk associated with 10-15 years or more of use (Kelsey, 1993). However, investigations of the risks associated with the use of oral contraceptives have yielded inconsistent results.

High levels of estrogen at certain ages during specific reproductive events in a woman’s life may also increase the risk of breast cancer. An early age at menarche (before 12 years old) results in a longer duration of exposure to estrogen during puberty and can increase the risk of breast cancer by approximately 1.2 when compared to women who began menstruation at 14 years of age and older (MacMahon et al, 1992, Harris et al, 1992). In addition, women who experience later menopause (after the age of 50) also have a slightly increased risk (ACS, 1998). The combined effect of an early menarche and a late menopause causes a longer exposure to estrogen and progesterone which have been associated with an increase in risk (Lipworth, 1995). Women that have been actively menstruating for 40 or more years are thought to have twice the risk of developing breast cancer than those with less than 30 years of menstrual activity (Henderson, et al, 1996). Also, the risk of breast cancer has been shown to increase linearly with age at first live birth. Women who gave birth for the first time after age 30 have shown a four-to-five fold excess in risk compared to those gave birth for the first time prior to 18 years of age (Brinton, et al, 1983).

Several benign breast diseases have also been associated with the onset of breast cancer. The most common type of benign breast disease is chronic cystic or fibrocystic disease. Women with cystic breast disease have been found to have a two-to-three fold increased risk of developing breast cancer (Henderson, et al, 1996). In addition, certain types of benign breast disease have been associated with an increase in a woman's risk of breast cancer.

Diet, particularly fat intake, is another factor suggested to increase a woman's risk for breast cancer. Currently, it is thought that the type of fat in a woman's diet might be more important than the total fat intake (ACS, 1998; Wynder et al, 1997). Monounsaturated fats (olive oil and canola oil) are related to a lower risk and polyunsaturated fats (corn oil, tub margarine) and saturated fats in meat are linked to an elevated risk (ACS, 1998). With respect to a woman's individual weight, the risk of breast cancer becomes less clear (ACS, 1998). Many studies have found that a heavy body weight elevates the risk for breast cancer in postmenopausal women (Kelsey, 1993). In postmenopausal women who are obese, the principal source of estrogen in the body is fat tissue (McTiernan, 1997). Regular exercise is thought to reduce the exposure to cyclic estrogens and progesterones, hormones believed to play an important role in the carcinogenesis of the breast (Thune, et al, 1997).

Alcohol consumption has been shown to be directly related to an increased risk of breast cancer (Swanson et al, 1996; ACS, 1998). However, this relationship still needs further evaluation. Women who consumed one alcoholic beverage daily in comparison to non-drinkers had a very small increase in risk, but those who had 2 to 5 drinks daily had about 1.5 times the risk compared to women who drink no alcohol (ACS, 1998). Furthermore, it is known that alcohol consumption affects the endocrine system, but the effects of alcohol on estrogen metabolism have not been fully investigated (Swanson et al, 1996).

To date, no specific environmental factor has been positively associated with the development of breast cancer although a variety of research efforts in Massachusetts and elsewhere are ongoing. The role of cigarette smoking, among other environmental factors, in the development of breast cancer is not clear. Some studies suggest a relationship between passive smoking and an increase risk of breast cancer; however, the lack of evidence from studies that include direct smoke exposure make it difficult to confirm this association (Laden and Hunter, 1998).

Individual exposure to high dose radiation can pose a risk of developing breast cancer. High-dose exposures to ionizing radiation have been shown to cause cancer from studies of survivors of the atomic bomb blasts in Hiroshima and Nagasaki as well as patients that have been subjected to radiotherapy in treatments (for tuberculosis, post-partum mastitis, and cervical cancer) (Laden and Hunter, 1998). However, it has not been shown that radiation exposures experienced by the general public (people living in areas of known elevated radiation levels due to industrial accidents or nuclear activities) are related to an increase in breast cancer risk (Laden and Hunter, 1998). In addition, investigations about electromagnetic field exposures in relation to breast cancer have been inconclusive.

Evaluations of certain occupations have not clearly identified any specific risk factors pertaining to breast cancer (Goldberg and Labreche, 1996). The of risk of developing breast cancer among nuclear workers who are exposed to ionizing radiation (Goldberg and Labreche, 1996), and the risk of a chemist or other women exposed to extremely low frequency electromagnetic fields (Goldberg and Labreche, 1996) as well as the relationship between solvent exposure and occupations, such as dry cleaning workers and shoe manufacturers, have been investigated but have not provided enough supportive evidence to determine an association with breast cancer (Goldberg and Labreche, 1996).

Exposure to chemical substances has been suggested as being related to an increased risk of breast cancer. Exposure to some chemical pollutants such as chlorinated hydrocarbon pesticides, DDT, DDE, and PCBs is suspected of increasing breast cancer risk. It has been hypothesized that because these compounds are weakly estrogenic (affect estrogen production and metabolism) they can increase the risk of breast cancer (Davis et al 1993; Laden and Hunter, 1997). Studies on breast cancer and exposure to certain pesticides have provided inconclusive evidence but such exposure still may represent a potential risk factor for breast cancer. To this end the MDPH is conducting a study in the Berkshire County area of Massachusetts to learn more about the possible association between PCB and DDT exposure among women diagnosed with breast cancer.

Despite the vast number of studies on the causation of breast cancer, known factors are estimated to account for approximately 50% of breast cancer in the general population (Madigan et al, 1995). Researchers are continuing to examine potential risks for developing breast cancer, especially environmental factors. The MDPH is currently working on a number of studies in Massachusetts exploring the relationship of breast cancer and environmental factors.

B. Leukemia

In Marblehead, the incidence of leukemia was statistically significantly elevated overall and in CTs 2031 and 2032. However, when evaluated by census tract for males and females separately, no specific pattern of elevation was observed. In Swampscott, the incidence of leukemia occurred less often than expected in the town and the two census tracts. Review of the age distribution of leukemia cases in both towns showed a pattern similar to what would be expected based on the epidemiology of this cancer type. In addition, the distribution of leukemia according to histologic type did not reveal an unusual pattern of incidence of this cancer.

Leukemia literally means "white blood cell"; a reference to the excessive numbers of white blood cells or leukocytes in the peripheral blood of individuals diagnosed with leukemia. The serious symptoms of the disease, however, are caused by a lack of normally functioning cells and/or platelets. This deficiency is brought about through the proliferation of cells that resemble a stage in normal blood cell development but are incapable of performing the functions of mature blood cells (Miller et al. 1990, Clarkson 1980). These functions include fighting off foreign invaders to the body by attacking them or releasing harmful substances.

Leukemia is a group of malignancies of the white blood cells, classified as separate histologic or cell types. Epidemiologic studies have shown that each histologic type of leukemia is an individual disease with specific characteristics, patterns of survival, and etiologic factors. There are four major subtypes into which most histologic types of leukemia can be categorized: acute lymphoid leukemia (ALL); chronic lymphoid leukemia (CLL); chronic myeloid leukemia (CML); and acute myeloid leukemia (AML). Epidemiologic research over the past twenty-five years has revealed patterns of incidence and risk factors that vary for each subtype. While there are known and suspected risk factors for each subtype, leukemia cases are relatively rare, and despite a large body of research, risk factors that have been identified for different leukemia subtypes only account for a small percentage of cases (Linet, 1985).

ALL occurs predominantly in children. Incidence rates drop off among middle-aged people, and increase again among older individuals (ACS, 1995). The known risk factors for ALL are ionizing radiation and benzene exposure. Suspected risk factors are genetic, viral, environmental, and occupational. Studies indicate that acute leukemias (ALL and AML) occur at an increased rate in a variety of congenital disorders including Down syndrome and Klinefelter's syndrome (Scheinberg and Golde, 1994). Other research has supported viral factors. However, a specific viral agent has not been identified. An increased risk of childhood ALL has been associated with exposure to several chemicals and possible paternal occupational exposure to hydrocarbons (Linet,

CLL is chiefly an adult disease; 90% of cases occur in people over 50 years old. CLL is the most common type of leukemia in the United States and occurs more often in males than females (Miller et al., 1990). Adult T cell leukemia is a type of CLL caused by a virus, Human T-Cell Leukemia/Lymphoma Virus-I (HTLV-I). The only known risk factor for other types of CLL is exposure to benzene. No association has been found between CLL and exposure to ionizing radiation (Linet, 1985: Scheinberg and Golde, 1994). Studies showing strong patterns of incidence in families suggest a genetic etiology. An association between CLL and autoimmune diseases suggests that immunologic factors may play an important role. Several viruses linked with leukemia in animals have been shown to cross species barriers; research suggests that human proximity to sick farm animals and pets may increase the risk of CLL. Rubber workers, and particularly tire builders, have a higher incidence of CLL. Exposure to some chemical wastes in the environment may also be a risk factor (Linet, 1985; Scheinberg and Golde, 1994; Schottenfeld and Fraumeni 1996).

AML may occur in children up to the age of 19, with incidence increasing rapidly beyond age 20. The known risk factors for AML are similar to those for ALL: exposure to ionizing radiation and benzene (Linet, 1985). Recent studies suggest that viral and genetic factors play a less important role in the development of AML than in ALL and CLL. Suspected risk factors for AML include occupational and environmental exposures and certain drug therapies, such as chloramphenicol and phenylbutazone (Linet, 1985). Suspected chemical exposures include petroleum products and organic solvents. AML as a secondary malignancy is increasing among people who have previously had non-Hodgkin's lymphoma, multiple myeloma, breast cancer, ovarian cancer, and lung cancer. A high risk of secondary AML in people who have had Hodgkin's lymphoma has also been documented. However, it is uncertain whether secondary AML is a result of chemotherapy and/or radiation treatment for a previous cancer, or whether secondary AML occurs as part of the natural history of the previous cancer in an individual for whom improved cancer therapy may have lengthened survival time (Linet, 1985). Cigarette smoking has also been identified as a possible risk factor in the development of AML (Siegel, 1993) Review of the geographic distribution of leukemia cases in Marblehead and Swampscott revealed no apparent pattern in relation to proximity to hazardous waste sites or other environmental sites of concern.

Of all the leukemias, CML is among the least understood. CML is an acquired genetic disorder, characterized by the presence of the Philadelphia chromosome. CML can occur at any age, but is most often observed in people between 30-50 years old. The only known risk factor is exposure to ionizing radiation, based on studies of atomic bomb survivors (Golde and Guliti, 1994). Occupational exposure to benzene has also been associated with the development of CML; however a causal relationship has not been established. Exposure to other chemical agents in the work place or environment is suspected in this disease (Linet, 1985). Cigarette smoking is also suspected in the development of CML; however the association is weak at best (Siegel, 1993). Current research has suggested that heredity and immunologic factors do not appear to be important in the development of CML (Linet, 1985).

Hairy cell leukemia is an uncommon type of leukemia, which is predominantly seen in males at an average age of 55. Although very little is known about the etiology of this disease, hairy cell leukemia has an excellent survival rate because of a new and relatively non-toxic treatment. The majority of cases experience complete remission and live more than ten years after diagnosis (ACS, 1996). Lymphosarcoma cell leukemia is uncommon. Immunologic factors are suspected in the development of this type of leukemia (Linet, 1985).

C. Melanoma

Melanoma was statistically significantly elevated in the town of Marblehead overall during 1987-1994. In addition, statistically significant elevations in melanoma among females in CT 2032 and males in CT 2033 were also noted in Marblehead. In Swampscott, the incidence of melanoma was elevated in CT 2022 but not statistically significant.

The incidence of malignant melanoma increases with age and rises steeply until the age of 50. Melanoma occurs slightly more often in females than in males (Armstrong and English, 1996). The incidence of malignant melanoma is higher among whites and lighter skinned individuals than dark-skinned individuals such as Africans, Asians, and Polynesians. The primary risk factor for melanoma is excessive exposure to ultraviolet radiation (i.e., the sun) for individual skin type. Several recent studies have found significantly increased risks of melanoma following repeated severe (i.e., blistering) sunburns, particularly during childhood and teenage years (Holly et al. 1995, NCI 1996). Freckles, an indicator of sun sensitivity and sun damage, are also associated with increased risk (Holly et al. 1995, NCI 1996). Factors associated with increased risk of melanoma include: a history of sunburns, fair skin, number of moles, presence of dysplastic or other atypical moles, previous melanoma, family history of melanoma, and immunosuppression (Holly et al. 1995, NCI 1996).

In both Marblehead and Swampscott, the sites where the majority of the tumors occurred were at locations on the body where melanoma would most likely be expected given excessive sun exposure; predominantly the torso for males, and lower leg for females. These patterns are consistent with American Cancer Society and national surveillance system data (ACS 1996).

VIII. CONCLUSIONS

Analysis of breast cancer, leukemia and melanoma incidence during 1987-1994 in Marblehead by census tract showed that all three cancer types were significantly elevated (compared to statewide incidence) in CT 2032. The only other significantly elevated rates, at the census tract level, were leukemia in CT 2031 and melanoma in CT 2033. Analysis of the geographic distribution of the residences of individuals with breast cancer or leukemia showed no obvious concentrations; the density of cases was generally consistent with population density.

In Swampscott, the SIR for breast cancer during 1987-1994 was significantly elevated and the rates were nearly equal in the two census tracts. Melanoma incidence was greater in CT 2022, which includes all of the coastal areas. No SIR was calculated for leukemia in CT 2022, because there were two few cases. Analysis of the geographic distribution of the residences of individuals with breast cancer or leukemia showed no obvious concentrations; cases were distributed evenly throughout the town.

The elevation in breast cancer in Marblehead was primarily due to a significant elevation observed in CT 2032, located in the central portion of the town. The increased incidence was largely due to increases among older age groups and no specific geographic pattern of cases was observed.

Review of demographic and reproductive information related to socioeconomic status, birth rates, mean age at first birth, and parity (number of births) indicate that the communities of Marblehead and Swampscott display a pattern of increased prevalence of these risk factors in comparison to the state as a whole. These factors probably explain a substantial portion of the observed elevations of breast cancer in these two towns.

With the exception of melanoma in Marblehead CT 2033 and in Swampscott CT 2022, no specific spatial or geographic pattern of any of the cancer types was observed in the towns of Marblehead or Swampscott or any of the census tracts that further subdivide the two towns.

In CT 2033, melanoma cases were not geographically concentrated in close proximity to each other but generally appeared concentrated along the eastern shoreline in this area. Further, the pattern of incidence of this cancer type (i.e., age and location of cancer) in both Marblehead and Swampscott was consistent with excessive sun exposure.

No geographic pattern or concentration of breast cancer, leukemia or melanoma in Marblehead or Swampscott was observed in relation to the location of hazardous waste sites, the projected maximum impact areas of the Salem Harbor Generating Station (SHGS) or other environmental sites of concern. In particular, no pattern of increased cancer incidence or geographic concentration of cases was observed in CT 2033 in Marblehead in the likely areas of maximum impact of emissions from the SHGS.

With the exception of melanoma in both Marblehead and Swampscott, the information reviewed in this evaluation suggests that no single factor was primarily responsible for the increased incidence cancer in the two towns. The findings presented in this report suggest that a number of factors such as early detection, reproductive behavior and other factors related to socioeconomic status may have played a role in elevated breast cancer rates in these communities.

In general, the available modeling and ambient air monitoring information indicate that average concentrations of criteria pollutants have not exceeded the health-based national ambient air quality standards established by the USEPA. However, little data are available for power plants in general, including the SHGS, with respect to other hazardous air pollutants (HAPs) that may be emitted by these types of facilities. It is not known to what extent HAPs that are persistent in the environment (e.g., mercury, dioxins) may have been emitted from the SHGS historically such that these emissions may have resulted in elevated concentrations in environmental media in nearby areas.

IX. RECOMENDATIONS

1. Women in Marblehead should be considered for inclusion in a larger MDPH investigation designed to evaluate environmental impacts and their potential relationship to breast cancer across other Massachusetts communities.
2. Due to statistically significant elevations in the incidence of melanoma and the geographic pattern of these cases in the town of Marblehead, the MDPH recommends that the Marblehead Board of Health work with the MDPH Cancer Control Program to develop an education and outreach program for the prevention of melanoma incidence in the town. This is particularly important for residents of CTs 2032 and 2033.
3. In order to further address community concerns and uncertainties about historical emissions from the SHGS, the MDPH recommends that an environmental sampling plan should be designed to analyze soil samples from these areas as well as a background area for selected contaminants.
4. Through use of the MCR, the incidence of breast cancer, leukemia and melanoma will continue to be monitored.

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